MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2016/2017

ETM7186 – ADVANCED NETWORK ARCHITECTURES AND PROTOCOLS

M.Eng. (Telecommunications)

2 JUNE 2017
3:00 PM – 6:00 PM
(3 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 7 pages (including this cover page) with 5 Questions only and an appendix.

2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please print all your answers in the Answer Booklet provided.

Question 1

a. Consider a TCP connection between Host A (sender) and Host B (receiver) over the topology shown in Fig. 1. The bit rate of each link and the processing delay of each intermediate node and Host B are shown in the same figure.

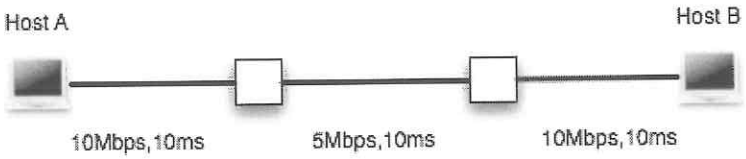

Fig. 1

Assume that packets are lost along the connection with a constant probability, p = 0.05. If a packet size of 1500-byte is used, estimate the average sending rate of the TCP source based on

(i) the periodic packet loss model (by using the inverse square root p-law) [3 marks]

(ii) the aperiodic/detailed packet loss model [3 marks]

Assume a very small size of ACK packet such that its transmission time is negligible.

b. TCP was initially designed and optimized based on the characteristics of wired networks. In a wireless network, TCP throughput tends to be poorer than expected. Discuss the problems that lead to the poor performance of TCP in wireless networks.

[8 marks]

c. The following two proposals provide mechanisms to improve TCP performance over wireless networks. Discuss each of them in terms of their respective principle of working, strengths and weaknesses.

(i) Split TCP [3 marks]

(ii) Snoop TCP [3 marks]

Question 2

a. An interesting property of certain Markov chains is the existence of a limiting state probability vector. In order to study the long term behaviour of queueing systems, a few key terms are defined to provide systematic characterization of Markov chains. For the following terms within the context of a Markov chain, define and explain the consequence/implications with respect to the limiting state probability vector.

(i) Transient state [2 marks]

(ii) Irreducible Markov chain [2 marks]

(iii) Ergodic [2 marks]

Continued ...

Question 2 (continued)

b. The limiting probabilities $\{\pi_j\}$, of an ergodic Markov chain are often referred to as the *equilibrium* probabilities in the sense that the effect of the initial state distribution $\pi_j^{(0)}$ has disappeared. A 3-state Markov chain is shown in Fig. 2. The transition probability matrix **P** consists of elements p_{ij}, which are shown in the diagram.

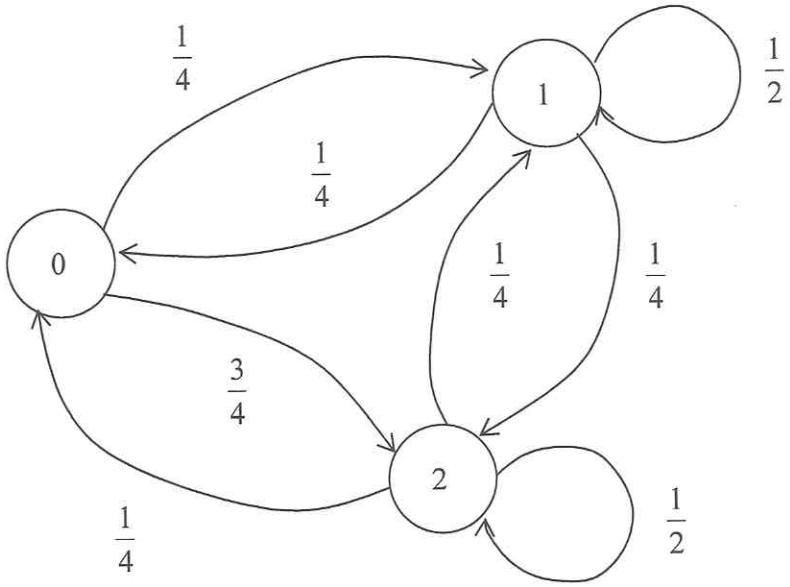

Fig. 2 A Markov chain

(i) Write down **P** in the form of a 3×3 matrix.

[2 marks]

(ii) The quantities $\{\pi_j\}$ can be uniquely determined through the equations

$$\pi_j = \sum_i \pi_i p_{ij}$$

$$1 = \sum_i \pi_i$$

Solve for $\{\pi_0, \pi_1, \pi_2\}$.

[12 marks]

Continued ...

Question 3

a. IP multicast services over the Internet face a number of deployment issues, which include the lack of access control in multicast group management. Discuss, with some suitable examples, the problems that could arise from this issue.

[4 marks]

b. (i) Application layer multicast (ALM) has emerged as a promising alternative to IP multicast in providing multicast services over the Internet. Differentiate between ALM and IP multicast.

[2 marks]

(ii) Define stretch and stress in the context of ALM.

[2 marks]

c. (i) Consider the topology shown in Fig. 3. Hosts A, B, C and D are members of a multicast group. Consider Host A as the data source.

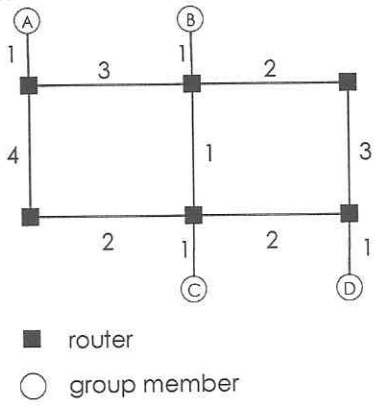

Fig. 3

Sketch the data delivery trees based on the computation assuming the following multicast methods:

1. IP multicast that uses Distance Vector Multicast Routing Protocol (DVMRP)
2. Application layer multicast (ALM) that uses Host Multicast Tree Protocol (HMTP)

Explain your solutions.

[6 marks]

(ii) Compute the stretch and stress values for each of the trees that you sketch above. Comment on the results.

[6 marks]

Continued ...

Question 4

a. A scheduling discipline allocates a share of the link capacity and output queue buffers to each connection it serves. For best-effort traffic, the desirable scheduling objective is to provide max-min fair share allocation.

(i) Compute the max-min fair allocation for a set of four sources with demands 2, 4, 10, 4 and weights 2.5, 4, 0.5, 1 when the resource has a capacity of 16. [8 marks]

(ii) Generalized processor sharing (GPS) is an ideal scheduling discipline that provides max-min fair share allocation. Consider a weighted round-robin (WRR) scheduling discipline which tries to emulate the ideal GPS. Suppose connections A, B and C have mean packet sizes of 50, 500 and 1500 bytes, and weights 0.25, 0.75 and 1.0, respectively. Calculate the number of packets that each connection should be served in each round by a WRR scheduler. [4 marks]

b. Integrated services (IntServ) and differentiated services (DiffServ) are two quality of service (QoS) architectures. Discuss the merits and demerits of providing QoS with the following two approaches:

(i) DiffServ at the network edges while IntServ at the network core [4 marks]

(ii) IntServe at the network edges while DiffServ at the network core [4 marks]

Question 5

a. The following is a statistical analysis on the confidence level of network simulation results. Suppose 10 observations are made from a normal distribution with unknown mean μ. They are: 1.20, 1.50, 1.68, 1.89, 0.95, 1.49, 1.58, 1.55, 0.50, and 1.09. Determine the 99% confidence level for μ. [6 marks]

b. The following investigates the number of simultaneous Voice over IP (VoIP) calls that can be placed in a single cell of an IEEE 802.11 wireless network. Imagine a scenario where n number of PCs are wirelessly connected to an IEEE 802.11 access point (AP), and a PC is connected to the same AP via Ethernet. n number of full-duplex VoIP calls are established between the wired PC and each of the wireless PCs using IP phones.

Under the IEEE 802.11 medium access scheme, the overhead of a frame is listed as follows:

Continued ...

Question 5 (continued)

Overhead	Bytes	Time (μs)
RTP Layer	12	$12 * 8/R_{avg}$
UDP Layer	8	$8 * 8/R_{avg}$
IP	20	$20 * 8/R_{avg}$
MAC	34	$34 * 8/R_{avg}$
Physical	24	$24*8/R_{avg}$
SIFS		$10\mu s$
DIFS		$50\mu s$
ACK	14	$14 * 8/R_{avg}$

Note the following denotations:
R_{avg}: Average data transmission rate of the AP
T_{layers}: Overhead of transmitting the extra bytes of various layers (including the preamble and header at the physical layer)
T_{SIFS}: Duration of one Short Inter-Frame Space (SIFS)
T_{DIFS}: Duration of one DCF Inter-Frame Space (DIFS)
T_{ACK}: Time taken to transmit one Acknowledgment (ACK) frame. Note that an ACK frame includes the overhead of the physical layer. Thus it consists of 14 + 24 = 38 bytes.
T_P: Time taken to transmit VoIP payload of P bytes
T_w: Time taken to transmit VoIP payload of P bytes and its overhead
T_{DCF}: Additional time required due to collision under the Distributed Coordination Function (DCF) of IEEE 802.11

For IEEE 802.11b, the duration of a slot is 20 μs, and let R_{avg} = 11 Mbps. The average back-off window size is 8.5 slots, and the collision probability is 0.03.
Suppose a VoIP call uses the ITU G711 codec of 64 kbps in one direction. For a duplex connection, it takes up 128 kbps. Given that P = 800 bytes, determine the followings:

(i) Maximum channel efficiency [8 marks]
(ii) Channel throughput [4 marks]
(iii) $n_{\max}$, the maximum number of VoIP connections [2 marks]

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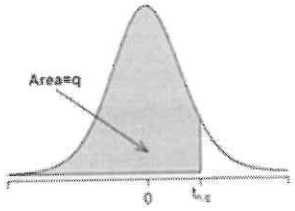
APPENDIX

Quartiles of the t Distribution

The table gives the value if $t_{n,q}$ - the qth quantile of the t distribution for n degrees of freedom



	q = 0.6	0.75	0.9	0.95	0.975	0.99	0.995	0.9975	0.999	0.9995
n = 1	0.3249	1.0000	3.078	6.314	12.706	31.821	63.657	127.321	318.309	636.619
2	0.2887	0.8165	1.886	2.920	4.303	6.965	9.925	14.089	22.327	31.599
3	0.2767	0.7649	1.638	2.353	3.182	4.541	5.841	7.453	10.215	12.924
4	0.2707	0.7407	1.533	2.132	2.776	3.747	4.604	5.598	7.173	8.610
5	0.2672	0.7267	1.476	2.015	2.571	3.365	4.032	4.773	5.893	6.869
6	0.2648	0.7176	1.440	1.943	2.447	3.143	3.707	4.317	5.208	5.959
7	0.2632	0.7111	1.415	1.895	2.365	2.998	3.499	4.029	4.785	5.408
8	0.2619	0.7064	1.397	1.860	2.306	2.896	3.355	3.833	4.501	5.041
9	0.2610	0.7027	1.383	1.833	2.262	2.821	3.250	3.690	4.297	4.781
10	0.2602	0.6998	1.372	1.812	2.228	2.764	3.169	3.581	4.144	4.587
11	0.2596	0.6974	1.363	1.796	2.201	2.718	3.106	3.497	4.025	4.437
12	0.2590	0.6955	1.356	1.782	2.179	2.681	3.055	3.428	3.930	4.318
13	0.2586	0.6938	1.350	1.771	2.160	2.650	3.012	3.372	3.852	4.221
14	0.2582	0.6924	1.345	1.761	2.145	2.624	2.977	3.326	3.787	4.140

Useful Formulas

Periodic packet loss model: $\overline{X}(p) = \frac{1}{RTT}\sqrt{\frac{3}{2p}}$

Aperiodic/Detailed packet loss model: $\overline{X}(p) = \frac{\frac{1}{p} + \sqrt{\frac{8}{3p} - \frac{5}{3}}}{RTT\left(\frac{3}{2} + \sqrt{\frac{2}{3p} - \frac{5}{12}}\right)}$

$\overline{X}(n) \pm t_{n-1,1-\frac{\alpha}{2}}\sqrt{\frac{S^2(n)}{n}}$

$T_w = T_P + T_{layers} + T_{SIFS} + T_{DIFS} + T_{ACK}$

T_{DCF} = (Average back-off window size × Slot time) + (T_w × Collision probability)

End of Paper